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Description

MORTAR PROJECTILE INSPECTION APPARATUS AND METHOD

FEDERAL RESEARCH STATEMENT

[0001] The invention described herein may be manufactured and used by or for the Government of the United States of America for government purposes without the payment of any royalties therefore.

BACKGROUND OF INVENTION

[0002] A mortar is an artillery piece having a relatively short smooth bore barrel which fires an explosive projectile in a high arched trajectory. The projectile is fin stabilized and a conventional projectile includes a relatively massive casing containing a propellant and an explosive charge which, upon detonation, causes fragmentation of the casing. In an improved design, the relatively massive casing is replaced by a light weight two-part configuration comprised of a composite structure surrounded by a shell of a light-weight metal such as aluminum.

[0003] The composite structure is a two phase structure having a filler of individual members, in the form of metal balls, contained in a matrix of thermoplastic. The composite structure has a longitudinal central cavity into which is placed an explosive charge. The arrangement provides for a greater lethality over the conventional projectile design.

[0004] The thin aluminum shell, however, is insufficient to withstand the acceleration forces when the projectile is launched and accordingly, the composite structure forms the structural element of the projectile. Since the metal balls are contained in a relatively weak thermoplastic matrix intended to fragment upon detonation, it is essential that the required amount of balls be placed in the matrix in a relatively homogeneous distribution. At the same time, areas where too many balls are packed tightly together might result in voids in other areas which can lead to structural failure causing the projectile to break apart after launch.

[0005] To date there has not been a relatively simple and accurate way to inspect the metal ball/thermoplastic composite structure prior to assembly. The present invention solves the problem.

SUMMARY OF INVENTION

[0006] The present invention relates to an apparatus and a method for inspecting a composite structure having a matrix and a filler of individual members subject to uneven distribution in the matrix, with the composite structure having a central longitudinal cavity. The composite structure is placed into a hollow cylindrical detection arrangement and a source of radiation is positioned within the central longitudinal cavity. The source of radiation is operable to project radiation toward the detection arrangement through the composite structure from the central longitudinal cavity. A detection medium carried by the detection arrangement surrounds the composite structure and is responsive to the radiation provided by the source of radiation to obtain an image of the distribution of the individual members in the matrix. The image is analyzed to determine acceptability of the composite structure.

BRIEF DESCRIPTION OF DRAWINGS

[0007] The invention will be better understood, and further objects, features and advantages thereof will become more apparent from the following description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which:

[0008] Fig. 1 is an exploded view of a mortar projectile.

[0009] Fig. 2 illustrates a composite structure within the mortar of Fig. 1.

[0010] Fig. 3 shows an apparatus for inspecting the structure of Fig. 2.

[0011] Fig. 4 is a cross-sectional view of the arrangement of Fig. 3.

[0012] Fig. 5 represents a result of an inspection.

[0013] Fig. 6 illustrates one type of analyses which may be used herein.

[0014] Fig. 7 illustrates another type of analyses which may be used herein.

[0015] Fig. 8 illustrates another embodiment of the present invention.

[0016] Fig. 9 illustrates yet another embodiment of the present invention.

[0017] Fig. 10 is a cross-sectional view of the arrangement of Fig. 9.

DETAILED DESCRIPTION

[0018] In the drawings, which are not necessarily to scale, like or corresponding parts are denoted by like or corresponding reference numerals.

[0019] Although the invention is applicable to the inspection of

various composite structures, it will be described, by way of example, in conjunction with a mortar projectile of the type illustrated in Fig. 1. In the exploded view of Fig. 1, projectile 10 includes a front end 12, containing a fuze, and, when assembled, is connected to a thin metal body 14, of aluminum, which receives a tail fin assembly 16. Disposed within the body 14 is a conformal composite structure 18 with a central longitudinal cavity into which is placed an explosive charge 20.

[0020] Fig. 2 illustrates the composite structure 18 in more detail. The outside surface of composite structure 18 conforms to the inside surface of the metal body 14 (Fig. 1) and forms the primary structural element of the projectile 10. The composite structure 18 is comprised of a filler of individual members such as metal balls 26, which may of steel, contained in a matrix 27, which may be of a thermoplastic material. These individual members may be of any size or shape, providing they can be packed into the dimension of the composite structure 18. In practice, however, steel balls of uniform diameter slightly less than the wall thickness of the composite structure 18 have been employed advantageously. The composite structure 18 includes a central longitudinal cavity 28, which is used

in the inspection process to be described herein, and which subsequently receives the explosive charge of the projectile.

[0021] In Fig. 3, the composite structure 18, shown in cross-section, is positioned within a detection arrangement 29 having a hollow tube 30, also in cross-section. Positioned within the central longitudinal cavity 28 is a source of radiation 34, such as visible light, infrared, ultraviolet or x-rays or any form of electromagnetic radiation. Positioned around the inside surface of hollow tube 30 is a detection medium 36, sensitive to the particular wavelength or wavelengths of the source 34. For example, if source 34 is a strobe light, then detection medium 36 would be photographic film. If the radiation source 34 produces X-rays, then the detection medium would be X-ray film.

[0022] With additional reference to Fig. 4 which is a radial cross-section (with elements shown in full before sectioning), when strobe light 34 is activated, the visible radiation, as depicted by arrows 38, propagates simultaneously in all radial directions and will be blocked or scattered by steel balls 26 and will be transmitted by thermoplastic matrix 27, which permits transmission of the light to expose film 36. Where there is a uniform distribution of steel balls 26

within the thermoplastic matrix 27 the transmission of radiation would be uniformly scattered resulting in a relatively uniform exposure on the film 36 which would show up as a uniform glow when the film is developed.

[0023] If however, there is an uneven distribution of steel balls 26, this would result in voids appearing in the matrix 27 allowing greater transmission of radiation thereby fully exposing the film 36 in areas where the film is opposite those voids. Where there is a high concentration of steel balls 26, a reduced transmission of radiation would take place and the film 36 would be substantially unexposed. A typical developed film 39 under these conditions is illustrated in Fig. 5 which shows brighter spots 40 where there has been direct transmission of radiation and darker areas 41 where the steel balls are congregated in the matrix.

[0024] A simple transparent grid 46, illustrated in Fig. 6, may be placed over the developed film 39 and could provide a quantitative indication of ball distribution. This may be accomplished by counting the resulting white squares and comparing that number with the total number of squares. Such an operation, however, is labor intensive and may only be applicable for relatively small production runs. A more automated arrangement is illustrated in Fig. 7.

[0025] After setting up the inspection, as in Fig. 3, the first step in the process, as indicated by block 50 is to activate the radiation source and expose the film surrounding the composite structure 18. Next, the film is developed as indicated by block 52. The developed film 39 is then scanned by a solid state camera 54 to obtain an electronic image of the developed film 39. Such electronic image is then analyzed by an algorithm in computer 56, which will then provide an indication of acceptability of the examined composite structure 18.

[0026] Some of the steps of Fig. 7 may be eliminated by the arrangement of Fig. 8, which may be used for large production runs. The detection arrangement 58 is comprised of a cylindrical sensor array 60 having a multitude of individual sensors 61 surrounding the composite structure 18. Each sensor 61 is responsive to the radiation provided by radiation source 34 and will provide an output signal indicative of received radiation. The collective outputs of all the sensors 61 are provided to a computer 62 for analysis, as in Fig. 6.

[0027] If a particular source of radiation provides highly directional radiation, as opposed to omnidirectional radiation, as in Fig. 4, then an arrangement such as illustrated in

Fig. 9 may be used. Radiation source 64 includes a slit 65 for projection of an elongated narrow beam of radiation. A motor 66 connected to the radiation source 64 rotates it while the radiation beam is being provided, to expose 360 degrees of film 36. The sectional view of Fig. 10 illustrates the source of radiation 64 with radiation beam 68 emerging via slit 65. Rotation of the source of radiation 64 by motor 66 moves the radiation beam 68 in the direction of arrow 70 for a full 360 degree of film exposure.

[0028] One skilled in the art would recognize that the exposure of the composite structure 18 to a form of actinic radiation could serve an additional purpose. Many resin materials are photo polymerizable and the actinic radiation might serve as a final curative step, to cross-link a thermoset resin or the like, or to promote micro fracturing which will aid in the uniform fragmentation of the composite structure 18 when an explosive charge is detonated within the structure.

[0029] Further, such actinic radiation might cure a surface coating applied to the inside surface of the composite structure 18, such as a coating intended to prevent interaction of the plastic matrix with the explosive fill during storage, or the like.

[0030] It will be readily seen by one of ordinary skill in the art that the present invention fulfills all of the objects set forth herein. After reading the foregoing specification, one of ordinary skill in the art will be able to effect various changes, substitutions of equivalents and various other aspects of the present invention as broadly disclosed herein. It is therefore intended that the protection granted hereon be limited only by the definition contained in the appended claims and equivalents. Having thus shown and described what is at present considered to be the preferred embodiment of the present invention, it should be noted that the same has been made by way of illustration and not limitation. Accordingly, all modifications, alterations and changes coming within the spirit and scope of the present invention are herein meant to be included.